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ABSTRACT

Recent criticisms of science education in the United States led to a unique experience in the Conroe Independent School District in Texas. An evaluation committee of local professional and eminent scientists was established by the local superintendent to review and evaluate the adequacy of (1) the scope and sequence of science courses; (2) laboratory and classroom facilities; (3) equipment and supplies; (4) student participation in science activities; (5) textbooks and teaching aids; (6) inservice opportunities; (7) student scheduling and counseling; (8) teaching force; (9) enrichment activities; and (10) library offerings, at the secondary and elementary levels. The committee visited science classes, counseled with participating students, and conferred with science teachers at all levels throughout the district. Findings include: (1) the high school teachers lacked current, state-of-the-art science knowledge; (2) the science courses needed improvements in six specific areas; (3) the laboratories needed larger physical facilities with more sophisticated equipment; and (4) there was a need to improve academic counseling of students with respect to science and mathematic course prerequisites. The changes that have resulted from the evaluation have led to improved instruction and support of science education in the district, and an ongoing relationship between the district schools, scientists, and the university programs. (Author/MD)

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# REVAMPING SECONDARY SCHOOL SCIENCE EDUCATION

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Paper presented at the National Convention of the Council of States on Inservice Education in Florida.

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REVAMPING SCIENCE INSERVICE SCIENTIFICALLY

ABSTRACT

A concerned citizenry has focused unpresidented attention on science education in public schools. The writers listened to the critics' reports cataloging concerns over an eighteen-month period. In an attempt to address the issues listed, an evaluation committee made up of local professional practitioners and eminent scientists from Rice University, Baylor College of Medicine, and the University of Houston was established to review the adequacy of: (1) Scope and sequence of science courses; (2) Laboratory and classroom facilities; (3) Equipment and supplies; (4) Student participation in science activities; (5) Textbooks and teaching aids; (6) Inservice opportunities; (7) Student scheduling and counseling; (8) Teaching force; (9) Enrichment activities; and (10) Library offerings. The consultants visited science classes, counseled with participating students, and conferred with science teachers over several days. The district constructed a plan addressing agreed upon needs and designed a comprehensive inservice sequence to be conducted by the district and the consultative personnel. This plan was presented to the Board of Education and the community through a series of workshop sessions within the school district and at the Baylor College of Medicine. The program has lead to improved instructional arrangements, staff morale, community knowledge and support of science education, and an ongoing relationship between the public schools, community scientists, and university programs.

# REVAMPING SECONDARY SCHOOL SCIENCE EDUCATION

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With the help of professional scientists on university campuses, in industrial settings, and in private practice, a few committed public school systems are beginning to move from obsolescing to exemplary science programs. At the recent National Convention of the Council of States on Inservice Education, the authors analyzed the unprecedented criticism currently lodged at science education in public schools and presented a case study resulting in a model proven effective in reviving instructional excellence, staff morale, community awareness, public support, and relationships among public schools, community scientists, and universities.

## The Problem

Perhaps the best summary of the critical status of public education can be found in the statement of Goldberg and Harvey (1983), two staff members of the National Commission on Excellence, that "a rising tide of mediocrity threatens to overwhelm the educational foundations of American society." Highlights of the profound document issuing this warning are as follows: (1) on nineteen international assessments of student achievement, U.S. students never ranked first or second -- in fact, when compared only with students from other industrialized nations, U.S. students ranked in last place seven times; (2) some twenty three million American adults are functionally illiterate; (3) about thirteen percent of U.S. teenagers (and up to forty percent of minority

adolescents) are functionally illiterate; (4) from 1963 to 1980 a virtually unbroken decline took place in average scores on the Scholastic Aptitude Test (SAT); (5) similarly, a dramatic decline took place in the number of students who demonstrated superior achievement of the SAT; (6) between 1975 and 1980 the number of remedial mathematics courses offered in four-year public colleges increased by seventy two percent; and (7) only about one-fourth of the recent recruits to the Armed Services were able to read at the ninth-grade level, the minimum necessary to follow safety instructions.

While the foregoing are general statistics, the current situation in science and mathematics education at the elementary and secondary school level is also under close national scrutiny. Hardly a day passes without either a major newspaper or magazine article appearing on the subject of the "crisis" in science education in our nation's schools. One such recent article appearing in Updating School Board Policies warns that elementary science is ignored in contemporary efforts to improve education. A recent survey of science instruction conducted by the American Association of School Administrators reflects that: (1) most elementary teachers give little attention to science; (2) most of these teachers are poorly prepared to teach science; and (3) most elementary classrooms lack appropriate facilities and equipment for teaching science (Brodinsky, 1984). Consequently, as confirmed in one study, elementary students' attitudes about science classes are less positive, with only fifty three percent indicating that they are excited about science classes (Rakow, 1984). Conditions are similar in our nation's secondary schools, as pointed out in an article published in

the NASSP Bulletin listing the major shortcomings in science and mathematics education: (1) only one-third of the school districts in the U.S. require more than one year of science or mathematics in grades 9-12 for graduation from high school; (2) most students have one or two years of general science in grades 7-9; (3) three-fourths of these students take biology in the tenth grade; (4) fewer than one-third take chemistry; (5) only one-sixth take physics, usually in the twelfth grade; and (6) more than half of all U.S. students either do not take algebra at all, or end their mathematics with first-year algebra (Brinckerhoff, 1982).

The implications of the preceding statements are significant in terms of this nation's ability to remain in a position of scientific and technological eminence in a global sense. Brunschwig and Breslin (1982) state that under current conditions, with an uninformed citizenry, we have reason to be concerned about our future. In emphasizing the seriousness of the problem, these two authors posed two compelling questions: (1) For how long can we escape a major disaster if we continue to postpone a decision about what to do with radioactive waste at the same time that we insist on generating power from uranium?; (2) For how long will we continue to bear the consequences of inadequate health care and nutrition for much of our population at the same time that we insist on hemodialysis for everyone in need at enormous public expense? One could generate a list of questions of this type that would go on for pages, all of which would have the common denominator of resolution based upon an informed citizenry guided by an academic and professional cadre of leaders with sufficient scientific and technological knowledge to develop sound approaches to problem solving. Many citizens cannot

even frame appropriate questions to ask about issues involving scientific and technological factors. Consequently, a significant fraction of the population is unable to participate wisely in political debates, vote intelligently, or contribute significantly to resolving the scientific and technological issues confronting society (Brunschwig and Breslin, 1982). While the literature is replete with similar statements regarding the national problem of too few science and mathematics takers in our schools, the citations used hereing are, in the writers' opinions, adequate to describe succinctly the background of the problem.

Attempts at ameliorating the alarming status of science and mathematics education in our schools will require initiatives that are multifaceted and comprehensive. No single program or effort will completely resolve a problem that has been developing over a period of decades. Included in the array of action necessary to effect change will be increased federal commitment to education and research, both in terms of funding and program planning; enhanced collaboration between public schools and private sectors designed to tap the wealth of scientific and technological expertise available in the private sector; a rededication to academic excellence at the local level; and the preparation of teachers who have the requisite academic knowledge and instructional skills to be optimally effective in the classroom.

Recent developments indicate that the essential components necessary for corrective actions are beginning to coalesce. New programs at the Federal level are being implemented to improve science education, private sector institutions and organizations are recognizing the need to become involved to insure an adequate supply of scientists and

mathematicians for the future, and school districts are developing innovative programs to improve the quality of mathematics and science education. The activities outlined in the ensuing pages describe one such effort.

## The Plan

It was during the summer of 1983 that public school administrators were beleaguered with no fewer than fourteen comprehensive nationwide reports on education, each painting the gloomy portrait of instructional failures outlined above. The Board of Education of the Conroe Independent School District, a system of 21,000 students just north of Houston, Texas, had taken careful note of the national studies and had created a special task force of local business and professional people to hear testimony from patrons, visit schools, study reports, and design specific recommendations for needed remediation of the district's programs. A new superintendent was charged with the task of revamping programs at the conclusion of the eighteen month Committee effort. Heading the list of priorities was science instruction.

The superintendent visited in science classes, met with teachers, interviewed students, reviewed the science curriculum, and studied test results. It seemed apparent that students were achieving on a competitive level with those in neighboring districts; yet, criticism persisted concerning the program. It became obvious that an in-depth investigation was appropriate; however, the traditional procedure of inviting science teachers from other systems to visit the district and make recommendations concerning program improvement seemed anachronistic. Since the focal point was science and the dissatisfaction was being

lodged from outside the public school arena, the superintendent decided to approach the scientific community for help; so an appointment was made with Dr. Ronald Sass, Chairman of the Biology Department at Rice University.

Professor Sass confirmed that the decline in science competency among young people was at a critical point. He agreed to assist personally in efforts to improve the status of science education within the school district, requiring only that the commitment be sincere and that any productive findings be shared with other interested systems. He encouraged the superintendent to approach Dr. Robert E. Roush, Head, Division of Allied Health Sciences, Department of Community Medicine at Baylor College of Medicine, who was both interested and experienced in partnership arrangements between the Medical School and public schools.

Within the week the superintendent was visiting with Dr. Roush and his assistant, Dr. William A. Thomson, to request their participation as additional consultants in a proposed team; but, the Baylor consultants offered more -- to approach colleagues at Baylor College of Medicine, Rice University, and the University of Houston and to assemble personally a uniquely eminent panel of scientists to conduct a comprehensive evaluation of science in the high schools of the Conroe district. It was agreed that, as the panel was being constructed, the superintendent would simultaneously select a representative group of scientists practicing within the district to join the committee, and also assemble an information packet for the evaluators to peruse prior to coming to the schools.

The coterie of specialists was finalized expeditiously (see Figure 1), as every person approached agreed without hesitation to assist with the project. The superintendent, in conjunction with the Baylor consultants, constructed a ten-component evaluation design which directed the "Board of Visitors" to review the: (1) scope and sequence of science courses; (2) appropriateness of enrichment activities; (3) adequacy of laboratory and classroom facilities; (4) comprehensiveness of the library; (5) availability of equipment and supplies; (6) suitability of textbooks and teaching aids: (7) student participation in science activities; (8) scheduling and counseling of students; (9) character of inservice efforts; and (10) quality of the teaching force. A deliberate effort was made by the superintendent to avoid exposing the panel to the traditional constraints contained in district policies and state and federal regulatory agency guidelines that might limit or contaminate their findings. A time-table of events was scheduled (see Figure 2) and the procedure was activated.

The second week was devoted to meeting with building principals, science department heads, and classroom teachers. It was essential that teachers feel a part of the process rather than accused by it. Wholesome dialogue was conducted during the second, third, and fourth weeks as the evaluation design was confirmed, the self-study materials addressing the ten components of the evaluation were collected, and final plans were agreed upon.

The most interesting and motivational aspect of the process was realized during the fifty week when the consulting panel visited the schools. It was difficult to determine whether visitor or resident was

Figure 1
Panel of Evaluators

| | |
|---|---|
| B. R. Brinkley, Ph.D.<br>Professor of Cell Biology, Department of Cell Biology at Baylor College of Medicine (Current President of the International Federation of Cell Biology) | Cell Biology, Anatomy, and Physiology |
| Zenaido Camacho, Ph.D.<br>Associate Dean for Academic Affairs at Baylor College of Medicine | Chemistry |
| Gene Chiappetta, Ph.D.<br>Associate Professor, Department of Curriculum and Instruction, and Director of Science Education at the University of Houston | Science Education |
| Marc H. Dresden, Ph.D.<br>Professor, Department of Biochemistry, and Assistant Dean, School of Graduate Sciences at Baylor College of Medicine (Recipient of Senior International Fellowship, Fogarty International Center, National Institutes of Health, 1977-78 and 1981) | Chemistry |
| Tom Fiorito<br>Chief Geologist for Exploration, Mitchell Energy Corporation, The Woodlands, Texas | Earth Science |
| Paul Pearce, Ph.D.<br>President of Pearce Clinical Laboratories, Conroe, Texas | Microbiology |
| Richard R. Roberts, M.D.<br>Local practicing specialist in obstetrics and gynecology, Conroe, Texas | Clinical Science |
| Robert E. Roush, Ed.D., M.P.H.<br>Director, Center for Allied Health Professions and Head, Division of Allied Health Sciences, Department of Community Medicine at Baylor College of Medicine | Project Design and Chairman |
| Ronald L. Sass, Ph.D.<br>Professor and Chairman of Biology, and Professor of Chemistry at Rice University | Life Science |
| Ronald Stebbings, Ph.D.<br>Professor of Space Physics and Dean of Undergraduate Affairs at Rice University | Physics |
| William A. Thomson, Ph.D.<br>Assistant Director for Research, Center for Allied Health Professions at Baylor College of Medicine | Academic Program Assessment |
| Carlos Vallbona, M.D.<br>Professor and Chairman, Department of Community Medicine at Baylor College of Medicine | Clinical Science |
| Robert P. Williams, Ph.D.<br>Professor and Director of Graduate Studies, Department of Microbiology and Immunology at Baylor College of Medicine (President, American Society for Microbiology, 1983-84) | Microbiology |

Figure 2

Time-Table of Events

| Time | Activity |
|---|---|
| Week 1 | Assemble panel and construct evaluation design |
| Week 2 | Meet with principals and department heads to confirm evaluation design |
| Week 3 | Complete self-study information packets and deliver to panel |
| Week 4 | Meet with panel and principals to review self-study and finalize plans |
| Week 5 | Conduct site visits |
| Week 6 | Meet with panel and principals to clarify questions |
| Week 7 | Meet with panel and principals to discuss preliminary draft of report |
| Week 8 | Final report submitted to C.I.S.D. |

the more enthralled as the scientists observed classroom instruction, discussed issues with teachers, interviewed students, took part in laboratory experiments, surveyed textbook selections, perused curriculum documents, and otherwise participated in the daily lives of secondary school people. Mutual awareness and respect were obvious as the participants, with self-study in one hand and note-pad and pencil in the other, proceeded through the week.

Principals, department heads, and central administrators met with the panel the following week to debrief the scientists and to supply any additional information requested. A preliminary draft of the evaluation findings was prepared and discussed at a subsequent meeting, and within ten days the final report was presented to the superintendent. At the conclusion of the two month study, the Conroe Independent School District Board of Education was invited to Baylor College of Medicine to hear the findings of the panel of scientists.

## The Findings

The major findings of the evaluation were grouped into four refreshingly simple categories: (1) teachers; (2) courses; (3) facilities; and (4) co-curricular areas. Each of the general areas was treated with remarks as to current status and recommendations for improvement.

The first of these examined considerations constitutes the most essential element in not only the current quality of science programs, but also in any hope for future improvements. The panel members were able not only to confirm the status of science faculty members as to state agency certification requirements, but also to determine with

unexpected clarity a profile of teachers' attitudes about teaching, dedication to science education, interest in acquiring new knowledge, willingness to work with teachers in lower grades, and eagerness to participate in program improvement. These feelings, so often unexposed in interaction with professionals in other disciplines, were revealed to the visiting colleagues as purely and naturally as a confidence entrusted to a friend.

The teachers in the District were perceived by the scientists to be reasonably well trained, appropriately certified, highly motivated, decidedly student-centered, and generally representative of science faculties found in quality secondary schools of the State. It was the observation of the visitors, however, that the high school teachers lacked current, state-of-the-art science knowledge, especially in modern, quantitative biology. This condition was due primarily to the failure of the District to maintain relevant inservice activities and professional growth opportunities addressing new knowledge.

The second of the areas evaluated, courses, generated enthusiastic response from the science panel. After reinforcing recent reforms and duly recording the comprehensiveness of both the scope and sequence of offerings, the scientists were able to assist the instructional program by suggesting improvements in: (1) the coordination of teaching efforts among the secondary schools of the District; (2) the continuity in science programming from kindergarten through senior year; (3) the reduction in the emphasis of classical biology in favor of stressing analytical, modern life sciences; (4) the comprehensiveness of syllabi

and course guides; (5) the efforts to reduce overdependence on obsolescing textbooks; and (6) the institution of more meaningful laboratory experiences.

The evaluation of physical facilities constituted the third division. Again, the committee found the facilities to be representative of most fine high schools, but major changes were recommended to achieve excellence. Larger laboratories were suggested which would permit labs set for specific experiments to remain for sufficient periods of time without hampering other teachers' scheduled use of the same room. Increased storage spaces, additional water fixtures and electrical outlets, and more sophisticated safety-related items were encouraged. The panel suggested guidelines whereby teachers could secure relevant supplies without the rigors of cumbersome purchasing procedures, and proposed the addition of laboratory assistants and secretarial aides.

The fourth aspect of the evaluation rested with attention to co-curricular considerations. A plethora of supportive statements were catalogued concerning related curriculum areas and instructional support activities, especially regarding library facilities and computer programs. A variety of findings, however, revealed specific indicators for improvement. The most pronounced of these was the need for additional academic counseling for students with respect to prerequisite science and mathematics courses. It was also determined that there was a need to improve appropriate interaction between counselors, science teachers, and parents with respect to science opportunities and career requirements. The team encouraged the three high school science chairpersons to devote more time to inter- and intra-school science improve-

ment activities. It was discovered that a significant number of students were electing not to participate in advanced level science courses due to overemphasis on certain requirements such as mandatory participation in science fair projects.

The secondary science teacher welcomed this potent confirmation of anticipated needs; and, the resulting evaluation document designed by the panel of scientists was, indeed, catalytic in securing an organized plan for instructional remediation and in rallying community support for the effort.

## The Promise

In addition to the specific findings in the areas discussed above, the distinguished colleagues provided the District with a prospect for energizing secondary science education. One of the most pronounced components of excellence perceived by the panel is subsiderarity. The classroom science teacher must be intimately involved in designing, implementing, and evaluating science education. It is the teacher who plays the fundamental role in infusing new knowledge into the curriculum, encouraging more students to take advanced courses, and providing training for less experienced teachers. A more efficient means of providing meaningful, content-specific professional growth must be identified by the teachers based upon need practical to their circumstances. Access to scientists on university campuses and in private practice within the community must be maintained.

A second theme throughout the findings is the need for radical reform of the science curriculum. Elementary science instruction must be designed to enhance, rather than thwart, the child's interest in

science. A solid foundation of scientific facts and concepts flavored with motivational experimentation in the early grades will encourage greater participation in science classes at the secondary level. Comprehensive science content with appropriate scope and sequence from kindergarten through the senior year is fundamental. Critical examination of the basic core of science courses taken by the majority of students is essential. Biology should become the introductory course for high school students, and master teachers should be selected for its instruction, rather than religating them solely to gifted students or to advanced courses. Textbooks, too often out of date before they are available, should be supported with current guides, syllabi, and supplementary materials. The "field and stream" approach to science should be replaced with quantitative, analytical modern science instruction.

The school district must become committed to obtaining and maintaining exemplary science programs. A high priority must be placed on comprehensive laboratory facilities including safety-related features, analytical instrumentation, inventory systems, storage spaces, and relevant supplies. Provisions must be made to support these facilities with laboratory assistants and secretarial help. A centralized, magnet-type science program for gifted should be established allowing for more in-depth interaction among these students, their teachers, and visiting scientists. A district-wide administrator should be assigned to coordinate science activities, and an academic counseling process should be established to inform students and parents of science offerings and career opportunities.

This unique evaluation was a source of enjoyment to the visiting scientists and of vitality to the school district. The assimilation of the recommendations from the panel defines a course for improving science programs; the accommodation of them insures the promise of excellence.

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